Evolution of the parton dihadron fragmentation functions

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One of the major emerging observables that offer an insight into particle production in jets and the modification of this mechanism due to the passage of these jets through a dense medium are the correlations between two high momentum particles observed in the fragmentation of these jets. Dihadron correlations have indeed been measured recently in a variety of experiments: in DIS of large nuclei as well as in heavy-ion collisions.

To study systematically such phenomena, an extension of the single inclusive fragmentation formalism of QCD is required, to include correlations between pairs of particles produced in the same jet. The simplest scenario to study such functions is that of jet fragmentation in e^+e^- annihilation. The double differential cross section for the same-side production of two hadrons in the e^+e^- annihilation may be factorized into the well known hard cross section for $e^+ + e^- \to \gamma^* \to q\bar{q}$ with an invariant mass Q^2 and the quark dihadron fragmentation functions at that scale.

The definition and factorization of the dihadron fragmentation functions ($D_{q/g}(z_1, z_2, Q^2)$), involves identifying two hadrons (h_1, h_2) with nearly parallel momenta p_1 and p_2 (or momentum fractions z_1, z_2 with respect to the initiating parton) among hadronic states along the direction of one of the partons and replacing the remaining sum over hadronic states with a sum over the rest of all partonic states. Similar to the momentum sum rules for the single hadron fragmentation functions, one has the following momentum sum rule for dihadron fragmentation functions,

$$\sum_{h_1, h_2} \int dz_1 dz_2 \frac{z_1 + z_2}{2} D_{q;g}^{h_1 h_2}(z_1, z_2) = \frac{\langle N(N-1) \rangle}{\langle N \rangle}. \quad (1)$$

In the above, $\langle N \rangle$ and $\langle N(N-1) \rangle$ represent the event averaged multiplicity and number of pairs in the fragmentation of the given parton.

Similar to the single inclusive fragmentation functions, the dihadron fragmentation functions possess the property that they need to be measured experimentally at all values of z_1 and z_2 but only at a given energy scale and in a single experiment. They are process independent and assume the same values for the same set of input parameters (momentum fractions and energy scale) in all experiments. The theoretical input lies in the prediction of the change of these functions with energy scale. Such evolution equations for both the quark and gluon dihadron fragmentation functions were presented in Ref. [1]. These evolution equations for both the quark and the gluon dihadron fragmentation functions have a similar probabilistic interpretation as that for the single inclusive fragmentation functions. The equations are extensive and hence only selected graphical results will be presented here.

In the absence of experimental measurements of such functions in e^+e^- annihilation experiments and in the interest of
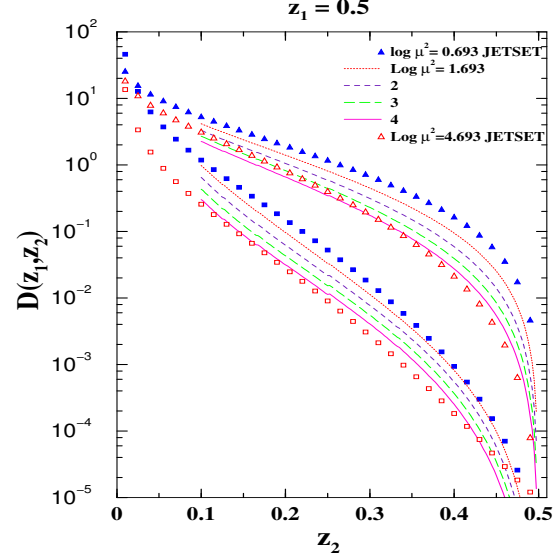

FIG. 1: Results of the evolution of the quark and gluon fragmentation function ($D_q(z_1, z_2), D_g(z_1, z_2)$). In all cases z_1 is held fixed at 0.5.

simplicity we turn to Monte Carlo event generators of jet fragmentation in e^+e^- collisions, for both the extraction of the initial conditions and for comparison to the numerical results of the evolution equation for dihadron fragmentation functions. We use the event generator JETSET based on the LUND model of string fragmentation. The results are presented in Fig. 1. The quark and gluon dihadron fragmentation functions are measured at a $Q^2 = 2 \text{GeV}^2$ ($\log(Q_0^2) = 0.693$). These are shown as the filled triangles for the quarks and the filled squares for the gluons. We have chosen a fixed leading momentum fraction $z_1 = 0.5$ and let the next-to-leading fraction z_2 vary from 0 to $1 - z_1$. Results of the evolution with energy scale are presented in increments of $\log(Q^2) = 1$. As expected, we note a softening of the spectrum with rising scale. We terminate the evolution at $\log(Q^2) = 4.693$, corresponding to scale $Q^2 = 109 \text{GeV}^2$. To compare the results of the derived evolution equations to that inherent in Monte Carlo event simulations, dihadron fragmentation functions at the highest scale are once again extracted from JETSET. The results are presented as open triangles for the quarks and open squares for the gluons. As shown they are in excellent agreement with the results of the evolution equations. This provides the most crucial test of the evolution equations. See Refs. [1, 2] for further details regarding the dihadron fragmentation functions.

[1] A. Majumder and X.-N. Wang (2004), hep-ph/0411174.
[2] A. Majumder and X.-N. Wang, J. Phys. **G31**, S533 (2005), hep-ph/0410078.